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# MELLON INSTITUTE



## Quarterly Report No. 7

From July 1, 1961 through September 30, 1961

on

## BALLISTIC PROTECTIVE BUOYANT MATERIALS

U. S. NAVAL SUPPLY RESEARCH AND DEVELOPMENT FACILITY
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Subjects under which report is to be indexed

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## SUMMARY

Orlon needled batts, 1.0 dpf, commercially processed at the Albany Felt Company were found to be ineffective buoyantly. Additional curing upgraded the material slightly; but a substantial increase in the buoyancy was obtained by "compartmentation", i.e. using 6" strips of the Orlon batt separated by plastic film to form larger sections.

The effect of various surface finishes on the ballistic performance of 42 oz./yd.$^2$ batts containing 1.0 dpf Orlon staple (3.0" cut) was investigated. The three finishes studied were the manufacturer's original anti-static agent, hydrophobed Aerogel and Decetex-104 silicone water-repellent. The ability of the batts to withstand fragment penetration increased as the fiber-to-fiber friction decreased.

A comparison of the ballistics of two types of 1.5 dpf Dacron staples, hydrophobed, was obtained. Type 5400 (cut to 3.0" lengths) was vastly superior to Type 64 (cut to 2.5" lengths).

A 50/50 blend of hydrophobed 0.5 dpf Acrilan (3.0" cut) and 1.5 dpf Dacron (Type 64 - 2.5" cut) was found to be equal ballistically to a 50/50 composite of the same materials.

# I. BUOYANCY EVALUATIONS

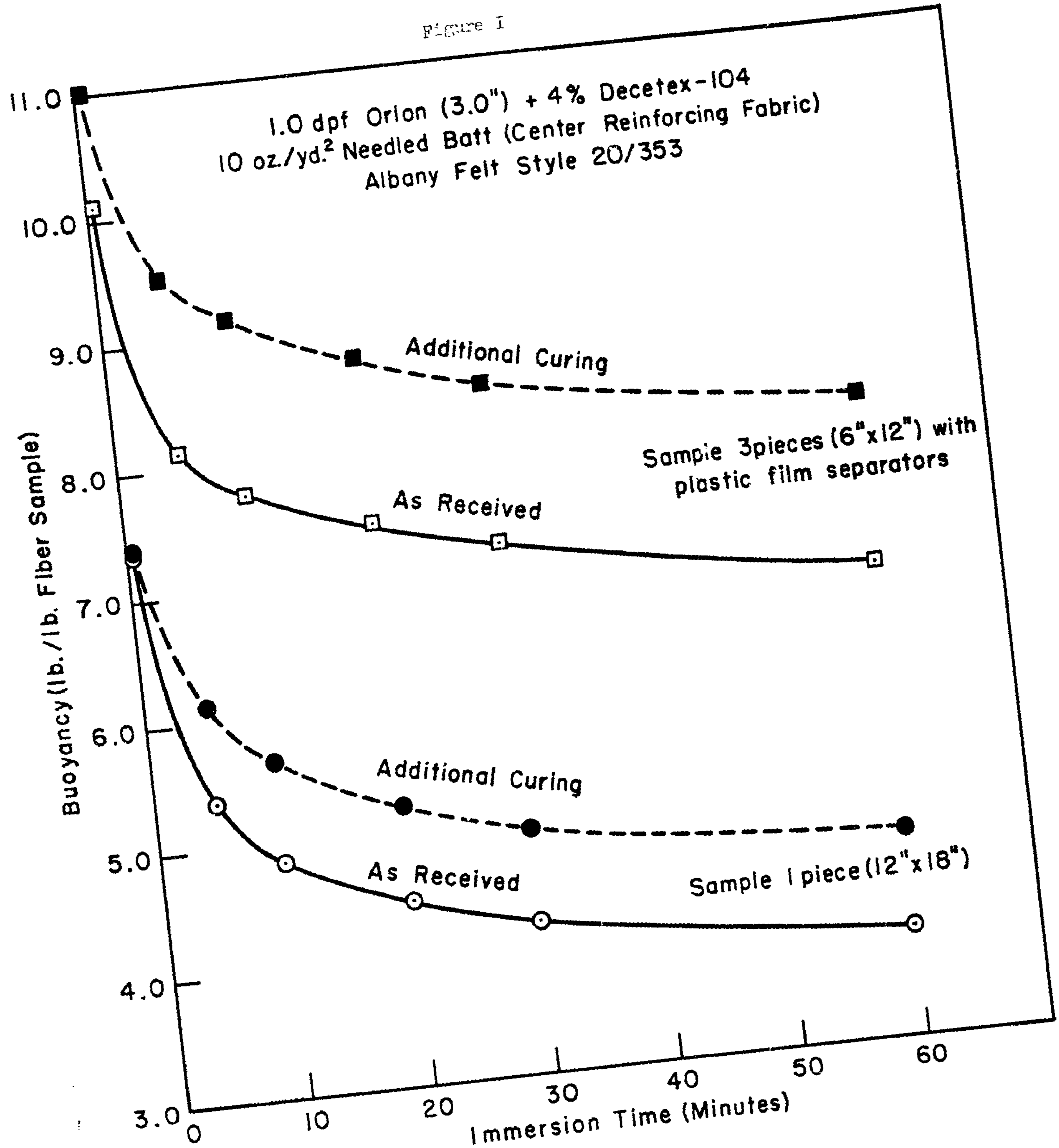
## A. Commercially Processed 1.0 dpf Orlon (3.0" Cut), Hydrophobed

A needled batt prepared at the Albany Felt Company for use as a possible buoyant liner, was found to lack sufficient buoyancy. This material consisting of 1.0 dpf Orlon (3.0" cut), had been hydrophobed with a silicone water-repellent and had been needled to a center reinforcing fabric with the resultant batt weighing 10 ounces/yd.$^2$ It was identified as the Albany Felt style 20-353. Since the lack of buoyancy would prohibit the use of this product, it was decided to investigate the possible cause or causes for its failure.

### (1) Effect of Additional Heat Curing

The most obvious possibility contributing to the lack of buoyancy could be the insufficient curing of the water-repellent onto the surface of the fibers. Therefore, after dry-cleaning with perchloroethylene, portions of this needled batt were subjected to a temperature range of 135° - 140° C. for a period of four hours. Static buoyancy tests were then made using both samples, as received and with additional curing, and the results plotted in Figure 1. It is evident that the additional curing did increase the overall buoyancy of the needled batt. However, a substantial increase was not obtained.

Figure I


1.0 dpf Orlon (3.0") + 4% Decetex-104
10 oz./yd.² Needled Batt (Center Reinforcing Fabric)
Albany Felt Style 20/353
Additional Curing
As Received
Sample 3pieces (6"x12") with plastic film separators
Additional Curing
As Received
Sample 1 piece (12"x18")
Buoyancy (lb./lb. Fiber Sample)
Immersion Time (Minutes)
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
0
10
20
30
40
50
60

(2) Effect of Wool Oil Contaminants

Previous experience with the buoyant products prepared by the Albany Felt Company has shown that a serious problem of contamination exists. The fibers as they are processed on the carding system at Albany, have always been found to be coated with oils that are normally associated with wool processing. Therefore, this obvious condition which could contribute to the lack of buoyancy in the present needled batts was investigated. The samples, as received, were dry-cleaned with perchloroethylene and thoroughly dried. A comparison of the static buoyancy of the dry-cleaned samples with those received indicated no improvement in the buoyancy. Evidently the contaminating oils, if present, exert insignificant influence upon the buoyant qualities of the needled samples in comparison with the insufficiently cured water-repellent.

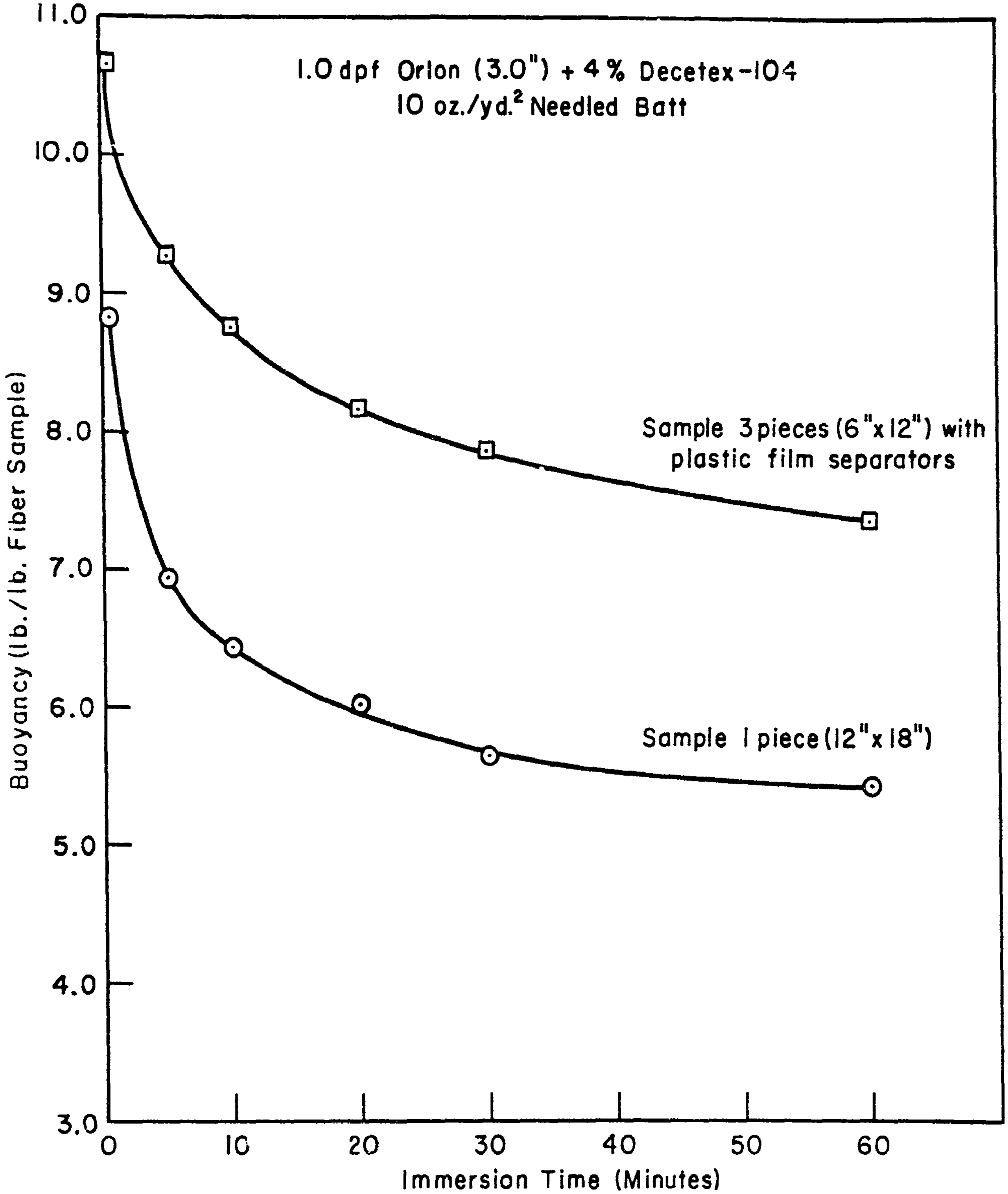
(3) Effect of "Compartmentation"

The dependence of buoyancy upon the column height of a fibrous sample, i.e., the length of the submerged fibrous sample perpendicular to the surface of the water, is well known. The column height or length of the liner samples tested in this laboratory have always been maintained at 18". This value is sufficiently large for all of the synthetic fibrous batts, to insure differentiation between the samples buoyantly. Drastic reduction of the column height results in

significant upgrading of the static buoyancy. The adaptation of the column height reduction to the problem of increasing the buoyancy of liner samples may be accomplished in several ways. As an example of one method, a sample of 18" in length may be divided into three 6" sections and then rejoined using water impermeable plastic film to separate the three divisions. The overall length of the resultant sample is therefore 18", equivalent to the original. The plastic separators serve to disrupt the column height. To illustrate the effect of this "compartmentation" upon the static buoyancy, one may refer to both Figures I and II. In each case, 10 oz./$yd.^2$ needled batts were subjected to the buoyancy tests as 18" samples and also as the "compartmented" type. In most cases an increase of over 3 lbs. buoyancy per pound of fibrous samples was obtained by using the plastic film separator.

This technique of "compartmentation" appears to be readily adaptable to the fabrication of jacket liners. Using 6" strips of the batt, large sections may be prepared by physically attaching these strips (by sewing or stapling) to each other with plastic film separators.

Figure II


1.0 dpf Orlon (3.0") + 4% Decetex-104
10 oz./yd.$^2$ Needled Batt
Sample 3 pieces (6"x 12") with plastic film separators
Sample 1 piece (12"x 18")
Buoyancy (lb./lb. Fiber Sample)
Immersion Time (Minutes)
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
0
10
20
30
40
50
60

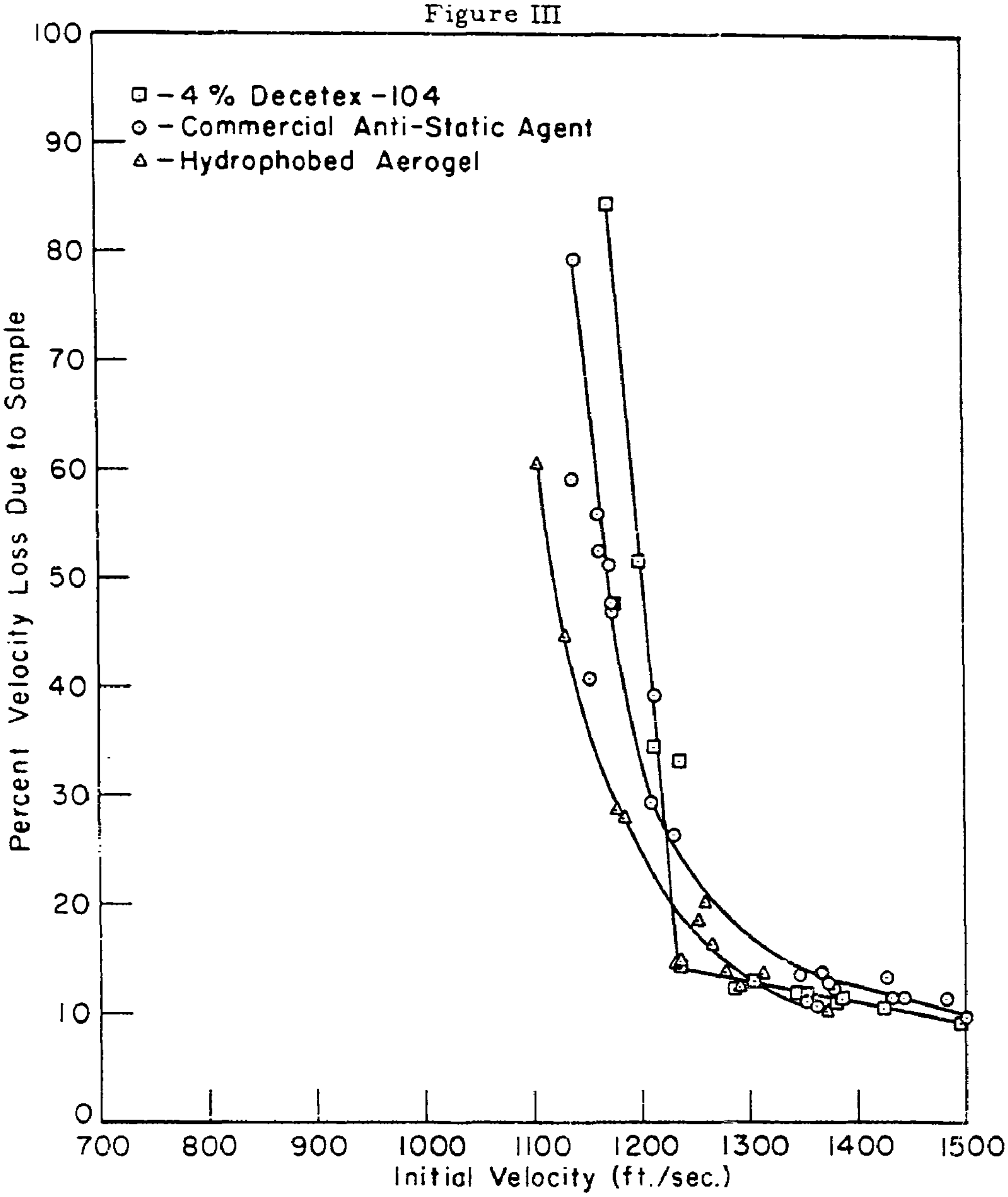
## II. BALLISTIC EVALUATIONS

### A. 1.0 dpf Orlon (3.0" Cut)

#### (1) Effect of Surface Finishes

Of the stamples examined to date, it appears that 1.0 dpf Orlon (3.0" cut) exhibits the highest ballistic performance. Originally in our test program, only hydrophobed Orlon fibers were tested, the presence of a water repellent being required for buoyancy. However, the effect of this finish and others upon ballistics is of great importance, both academically and practically. Consequently, various samples of the 1.0 dpf Orlon fibers were prepared having different surface finishes. All of the batts prepared were from the 3.0" cut staple having areal densities of 42 oz./yd.$^2$ In Figure III, the results of the comparison of the ballistics of three such samples are presented. The surface finishes on these three samples are as follows: the original anti-static agent as applied by the manufacturer, Decetex-104 water-repellent silicone, and hydrophobed Aerogel. A visual examination of these three samples show that the Decetex best reduces the fiber-to-fiber friction while the Aerogel increases the friction tremendously. The curve shown in Figure III may therefore by interpreted as showing that any increase in the fiber-to-fiber friction above that for the Decetex sample, lowers the ability of the batts to withstand fragment penetration.

Figure III




EFFECT OF SURFACE FINISH ON 1.0 dpf
ORLON BATTS (3.0" CUT) 42 oz/yd²

B. 1.5 dpf Dacron

(1) Type 64 vs Type 5400

For numerous reasons, manufacturers occasionally alter, chemically or physically, their commercial staple fibers. This we know can affect the ballistics of carded batts prepared from them. As an example, we have found that hydrophobed batts of 1.5 dpf Dacron-type 5400 (3.0" cut) are considerably superior ballistically to those containing hydrophobed 1.5 dpf Dacron-type 64 (2.5" cut). The results representing the ballistic performance of both types can be found in Figure IV. From data accumulated previously concerning the effect of staple lengths upon ballistics, the great difference in the ballistic efficiences shown by the two Dacrons, must be attributed mainly to the difference in their chemical or physical properties.

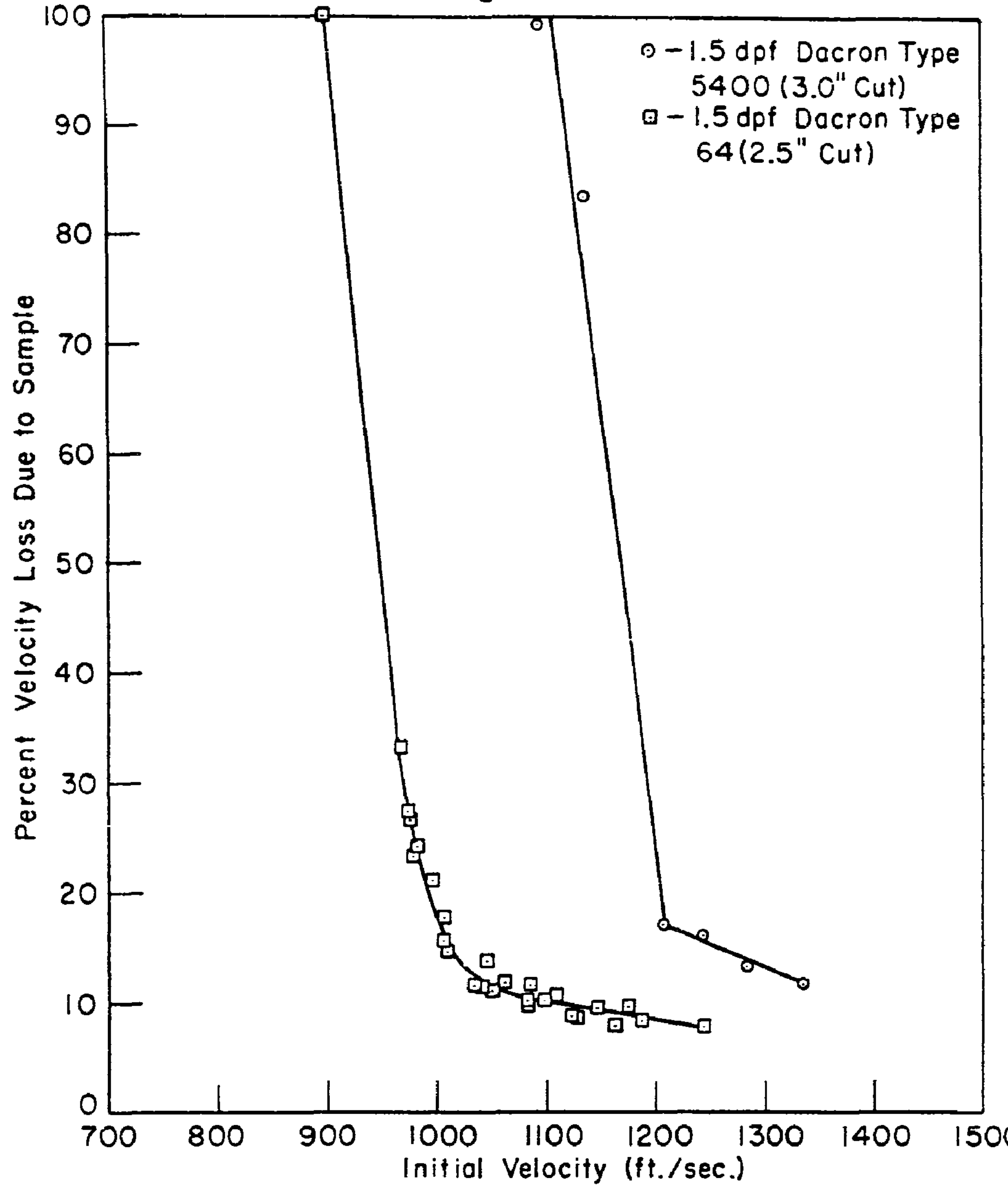
C. Admixtures, 0.5 dpf Acrilan with 15. dpf Dacron (Type 64)

The present phase of our ballistic investigation encompasses the preparation and testing of fiber blends and composites. Because of the availability in this laboratory, 0.5 dpf Acrilan fibers (3.0" cut) and 1.5 dpf Dacron (Type 64 - 2.5" cut) were used for the purpose of blending and the preparation of the composites.

(1) 50/50 Blend

Both the 0.5 denier Acrilan and the 1.5 denier Dacron staples were coated with a 4% finish of the Decetex-104 water-repellent

Figure IV




VARIATION IN COMMERCIAL DACRON STAPLE FIBERS 42 $oz/yd^2$

and then blended by carding at equal ratios, 50/50. These fibers were carded several times in order to insure adequate mixing. Using the carded batts at areal densities of 42 oz./sq.yd., ballistic tests were performed. The representative curve is presented in Figure V.

(2) 50/50 Composite, Acrilan in Front

Using the Decetex-coated Acrilan and Dacron staples, a 50/50 composite was prepared. This consisted of a 21 oz./$yd.^2$ batt of the Acrilan placed onto a 21 oz./$yd.^2$ batt of the Acrilan resulting in an overall areal density of 42 oz./$yd.^2$ This composite sample was tested so that the Acrilan was encountered first by the test projectile. The results of these tests are also presented in Figure V.

By referring to Figure V, one may perceive that the 50/50 blend and 50/50 composite are essentially equal ballistically and have the effect of totally upgrading the Dacron as well as increasing the limiting velocity of the 0.5 dpf Acrilan. The result of these tests may well direct our research activities towards the preparation of a blend or composite utilizing to the best advantage a highly buoyant fiber and an excellent ballistic fiber.

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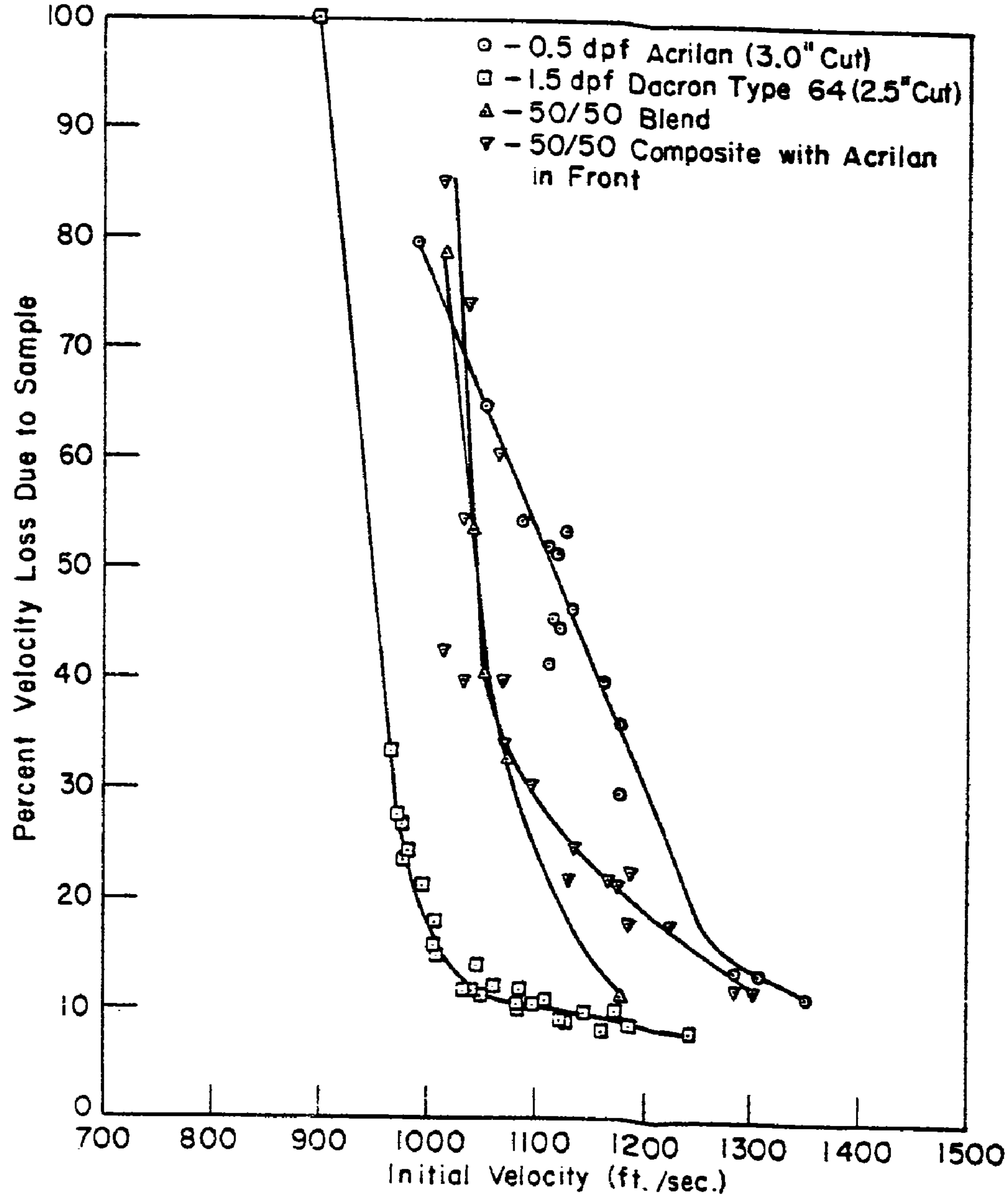
Figure V




FIBROUS BLENDS 42 oz/yd²